Education

The Lawrence Livermore National Laboratory Education Program, as a catalyst for change, facilitates partnerships and collaborations between LLNL and the global community to contribute to systemic improvement in science, math, engineering, and technology education; ensure a highly skilled, diverse workforce; and enhance scientific and technical literacy.

If the U.S. is to compete successfully in the world marketplace and remain a major economic power, it must have a workforce capable of understanding and applying the scientific and technological innovations that drive such competition. At LLNL, we are helping to shape that workforce through our collaborative efforts in science education. We are expanding the traditional science curricula, introducing new approaches to teaching science and math, enhancing science education through the use of technology, and providing students with opportunities to do research and earn advanced degrees. Our goals are to stimulate greater interest in science among students, teachers, administrators, and the public, and to encourage more students to pursue scientific and technical careers.

Dozens of LLNL scientists are participating in an LLNL program to become certified to teach grades K–12 in California public schools. Here, Lan T. Nguyen (right) is practice teaching at Granada High School in Livermore.

New Science Curricula

Since 1989, we have been working with schools and educators to design relevant science curricula that incorporate technology in teaching and learning. This year, our major accomplishments in curriculum improvement have been at the high school level. We have also succeeded in developing programs and courses at the junior college and elementary school levels. Many of these courses are multidisciplinary and cross over into less traditional areas of science, mathematics, engineering, and technology. All reflect our commitment to improving science education. Among those are the following four program summaries.

Global Climate Change Program

The Global Climate Change Program is a multidisciplinary curriculum in which elementary and high school teachers and students explore the physical aspects of the earth's climatic variations (for example, drought and atmospheric warming) and their social, political, and environmental effects as well. The entire curricula, developed by LLNL scientists and California teachers, received a thorough formative pedagogical review in 1994 by a group of university science educators from Oregon and Washington. The evaluators praised the creative and innovative ways used to study issues in global climate change; they also identified areas where the materials needed improvement to match "best practices" in education. Consequently, we are working to incorporate strategies for developing inquiry-based learning skills, integrating technology into the curriculum, and implementing strategies to use the curriculum to achieve systemic change in the instruction of science and technology. During FY 1994, over 50 teachers participated in workshops, including teachers from Louisiana and Georgia, and teachers from California, Nevada, and Utah who teach primarily Native American students.

The Biotechnology Education Program (BEP)

The Biotechnology Education Program is a high-school curriculum that deals with issues in biotechnology, including genetic engineering and ethics in research. Developed and implemented with educators, parents, and representatives from the biotechnology industry, the BEP is designed to impact student learning, teacher proficiency, and school-wide dynamic relationships. The program is a two-week series of multidisciplinary courses that can be integrated with and taught as part of different school subjects such as English, Spanish, and art, or coordinated with other school activities

such as school assemblies and "Back to School Night." The program was piloted in five local high schools in 1994, involving several thousand students. In FY 1995 this program will be introduced to eight high schools. In addition, we have proposed expanding this effort by establishing a network of BEP "hubs" across the country. Equipment and supplies would be provided by local partnerships between high schools and private/public institutions. We have established three possible nonlocal hubs: Tacoma, Washington; Richmond, California; and Sacramento, California. We are also entering into an agreement with a private company to develop BEP kits and publish BEP curriculum.

The Global Security Project

The Global Security Project, our latest addition to the science and math curricula, is a course of study that draws on the Laboratory's expertise in remote sensing and imaging technologies for use in arms control and treaty verification applications. Such technologies are used to track and capture electronic images of just about anything—from a large crater on the moon to a small cell in the human body. Students in this program have the opportunity to view such images on electronic media, such as the Internet or CD-ROM, and study relevant scientific principles such as light, lasers, and digital imaging. Recently they viewed the high-resolution images of the moon's surface taken by cameras on the Clementine satellite.[1] The educational CD-ROM will be available in early 1995.

Partnerships for Environmental Technology Education

In 1991, in an effort to improve environmental science and technology teaching at the junior college level, we established Partnerships for Environmental Technology Education. This program provides community colleges with the resources they need to develop training programs or college-prep curricula that will increase the number of qualified environmental scientists and technicians and promote environmental technology transfer. Currently, 40 community colleges in five states (Arizona, California, Hawaii, Nevada, and Utah) are participating in the program; however, with six new partnerships in the remaining 45 states, Puerto Rico, and the U.S. Territories, that figure will soon increase.

New Approaches to Teaching Science

The Laboratory offers a variety of programs and workshops to help teachers evaluate and enhance their approaches to teaching science. In the past, the emphasis was on the use of "prepackaged" kits and materials in the teaching of science. Although such tools are effective for rote teaching and learning, they do not encourage the creative thinking and problem-solving skills necessary to scientific investigation. Therefore, we have modified our programs to emphasize an inquiry-based approach to teaching.

Highlights for 1994

- Implemented the Global Climate Change Program, a multidisciplinary curriculum in which high school teachers and students explore the environmental, social, and political effects of the earth's climatic variations.
- Implemented the Biotechnology Education Program, a two-week series of high-school-level biotechnology courses that can be taught as part of other subjects or coordinated with other school activities.
- Implemented the Global Security Program, a high school science curriculum that draws on our expertise in remote sensing and imaging technologies.
- Worked with bilingual teachers from the Oakland Unified School District to design a science curriculum for elementary school students whose first language is Spanish or Chinese.
- Sponsored a number of inquiry-based teaching workshops to help teachers evaluate and enhance their approach to teaching science.
- Sponsored several K through 12 programs that enable students to explore science through cooperative research.
- Began developing software for distance learning, desktop video conferencing, and interactive learning.
- Began setting up a server that will enable the Laboratory's partners in education to communicate with the Laboratory directly and access the resources of the Internet.
- Began developing the software and engineering support that will be needed to access the Laboratory's scientific and technical resources.
- Implemented a program in which students are growing crystals to be used for laser research at the Laboratory.

Our Global Climate Change Program is one of LLNL's workshops that provides opportunities for local teachers to spend the summer at LLNL developing up-to-the-minute curricula for their science classes using inquiry-based learning skills.

In addition, we provide opportunities for educators to participate in summer-long internships as researchers in Laboratory programs and to experience first hand the scientific process and Laboratory research. Teachers return for multiple summers to continue their experiences and are encouraged to transfer their experience and new-found knowledge to the classroom, enrich curricula, and excite students with real-life applications and problems.

Science and Technology Inquiry Partnerships

A series of workshops prepares teachers to be partners in the systemic change process and allows them to develop and implement inquiry-based curricula for science and technology. In this approach, teams of teachers work with Laboratory scientists to apply the scientific method to a problem. First, teachers examine a problem, design their own theories to explain it, and suggest ways that they might go about solving it. Second, all participants work in groups to refine their theories and develop ways to test them. They then test their theories, revise them according to the test results, and retest them. Finally, they present their results, and use the knowledge gained through the process to explore other problems.

The goal is to have teachers use the process as a model for developing inquiry-based activities in the classroom. It also serves to move teachers who have little or no science background into a realm where they can teach science with confidence and finesse. This effort is implemented in two phases. The first, Introduction to Inquiry-Based Science and Technology, brings teachers from entry level to where they can use an inquiry-based curriculum in their classrooms. The second, Inquiry-Based Study of Science and Technology, brings teachers from the adoption level through the independent/adaptation level—where they can adapt curriculum to fit the individual needs of their departments—to a level of interdependence with other schools in their district so that they can implement innovative education reform.

Most of our inquiry-based teaching workshops are offered to teachers in California; however, this coming year we will be working with teachers in Louisiana, Georgia, Arizona, and New Mexico.

Fun with Science

In Fun with Science, LLNL scientists visit kindergarten through eighth grade classrooms and work with students' to present scientific experiments or demonstrations. Our goal with this program, as with others for this level, is to stimulate students' interest in science and heighten their curiosity about the physical world and the way it works. In keeping with our approach to promote systemic reform, this program is coordinated with our Science and Technology Inquiry Partnership workshops, so that teachers who have participated in it present the Fun With Science demonstrations to their students in tandem with LLNL scientific and technical staff. The teachers then continue promoting science and technology with their students, and the impact is sustained in the classroom. This year, more than 20,000 students have experienced Fun With Science activities.

Student Science Research Associates (SSRA)

We sponsor programs in which kindergarten through 12th grade students explore science through cooperative research teams and develop problem-solving skills necessary to succeed in the changing workplace. The goal is for students to form research teams and use computers and data recording and analysis tools to study complex global issues. They also use electronic communication networks to share ideas and discoveries with their research mentors at LLNL and with students who are doing similar research at other schools. For example, this school year students from several northern California school districts are conducting water-quality research in their communities and sharing their results via electronic mail. Teachers will guide student work in research teams to ask questions; gather background knowledge; develop a research plan; use technology to collect, analyze, and interpret

data; communicate results and findings; and develop community action plans. The current topic of study is water quality; partners include Adopt a Watershed and Global Rivers Environmental Education Network and its affiliated EcoNet, an environmental network and bulletin board.

An outgrowth of this effort is the International Science Partners project, a collaborative effort among LLNL, Los Alamos National Laboratory, and Oak Ridge Institute for Science Education. The program joins students and teachers from schools in North America with those from schools overseas in collaborative teams. Teachers and students have come from California, New Mexico, Texas, Tennessee, Mexico, and Obninsk, Russia. During summer 1995 we will be adding teachers (and their students) from Chelyabinsk-70 and Arzamas-16, Russia; Dresden, Germany; and the Hopi and Navajo Nations.

Improving Education through Technology

As a center for research and development, the Laboratory has always been committed to advancing technology and demonstrating its applications in science. Now we are extending this commitment to education. We are developing software for learning at a distance, desktop video conferencing, and interactive learning so that we can bring scientists and technical specialists "into the classroom." We established a server (on the Internet) so that our partners in education are able to communicate with us directly.[2] And, through our association with the Science Education Academy of the Bay Area[3]—a cooperative effort between the DOE and various Bay Area organizations to improve education through technology—we are developing the software and engineering support needed to access the Laboratory's scientific and technical resources.

In addition to developing educational technology, we are teaching students and teachers how to use it. For example, we run LLNL's Science Education Center, where students and teachers learn to use computers and telecommunications equipment by participating in a class or working on a special project. Since 1984, more than 2500 students and 500 teachers have taken advantage of this resource. We also offer summer workshops in which teachers can learn how to use the National Education Supercomputer (NES)[4] and how to apply supercomputing to the classroom. In the NES user workshops, the object is to turn out master teachers who train their peers and thereby extend access to the NES. In the application workshops, participants develop curricula that they can use for the next school year. At the end of the school year, each participant reports on his or her new curriculum, telling how it was used, whether it benefited the students or enhanced teaching methods, and how it can be improved for the following year.

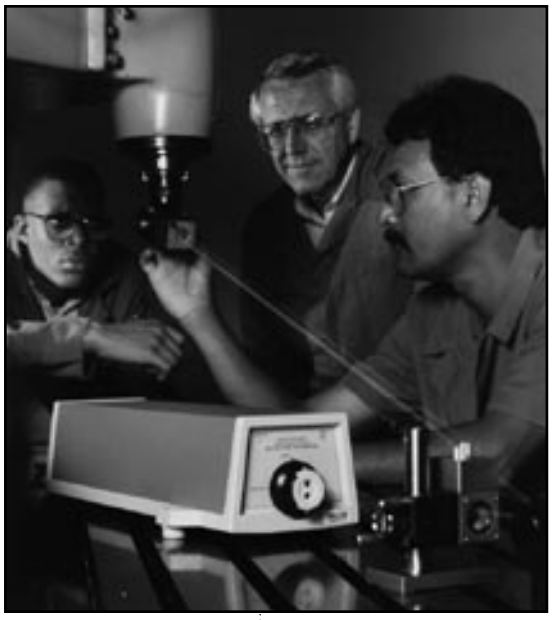
Students from Fort Valley State College, Fort Valley, Georgia, toured LLNL's National Energy Research Supercomputer Center and learned about our Cray computers. The visit was a part of our collaboration in the HBCU Cooperative Developmental Energy Program sponsored by the Department of Energy.

Opportunities for Research and Advanced Degrees

In the late 1950s, Dr. Edward Teller observed that government-supported basic science and industry cherished engineering, but no one laid claim to applied science—a body of knowledge that fell somewhere between the two and that depended on researchers who were well educated in several disciplines rather than one. Although by this time applied science had become the norm in research and product development, it still posed a problem: how to assure a continuous flow of R&D research talent when there were no institutions that "taught" applied science. Recognizing the need for such institutions, Teller and Roy Bainer, Dean of the College of Engineering at UC Davis, proposed having a graduate center in applied science at the Laboratory. In the fall of 1963, with the opening of the UC Davis Department of Applied Science, their idea became a reality.

The Department of Applied Science

The Department of Applied Science, now in its 31st year, combines traditional training in science with very progressive training in application. Students find the program attractive



College-level students reap collaborative research opportunities in our laser program as part of our work to shape the future scientific work force.

because it offers them a great deal of latitude: they may pick a thesis advisor from among several hundred researchers at the Laboratory, take all of their courses at the Laboratory from faculty or senior researchers, and, with the guidance of seasoned Laboratory professionals, perform their research using the Laboratory's unique facilities and equipment. Since 1963, 189 students have earned Ph.D. degrees. Of these, 57 work at LLNL, and another 26 worked at other national laboratories upon receiving their degrees.

Internships and Institutes

In addition to the graduate program in applied science, the Education Program offers a variety of internships and institutes. For example, through our association with the Associated Western Universities—a consortium of universities devoted to preparing students for scientific and technical careers in government, business, and industry—we provide an on-site program in which students choose their own projects and perform research under the supervision of Laboratory scientists. Approximately 50 students enter the program each year. They usually complete their internships over several summers and then seek employment. We are working with DOE to find out where these students ultimately are employed and what career paths they have chosen.

Every summer we offer a two-week institute to students in their junior year of college. The program is structured so that the students spend their mornings at lectures and their afternoons working with researchers on projects in applied physics, chemistry, mathematics, or engineering. At the end of the two weeks, the students present the results of these projects at a poster session. Since 1983, approximately 700 students from colleges and universities throughout the country have attended this institute.

We host the DOE Science and Engineering Research Semester, a program in which undergraduate students (women and minorities in particular) spend a semester as professional researchers at a national laboratory. At LLNL, these students spend 80% of their time on a Laboratory project and 20% of their time in seminars, technical communication workshops, and supercomputing courses. The intent of the program is to encourage the students to pursue advanced degrees and, ultimately, careers in science and engineering. Since the program was implemented, we have sponsored over 60 students from all over the U.S. The students receive a stipend for their work and credit for the supercomputer course. Many of the students also are able to receive credit for their research through their undergraduate institutions.

Targeting Diversity

Many of our college-level programs are specifically designed to encourage a wider and more diverse segment of the student population to pursue careers in science and engineering. For example, since the early 1970s, we have been helping historically black colleges and universities[5] enhance their science and engineering programs through the loan or donation of equipment and the presentation of workshops, seminars, or conferences. Over the last few years, the focus of our relationship with these institutions has been on collaborative research. This year, we implemented a program at Fisk University in which students are growing crystals to be used in laser research at the Laboratory. We also facilitated a collaboration between Spelman College and Morehouse College (both of Atlanta, Georgia) that has resulted in a new physics project. The experimental work for the project will be done at Spelman, the theoretical research at Morehouse.

Through our collaboration with the American Indian Science and Engineering Society, which began formally in 1982, we are helping the Navajo Community College revamp its science program, and we are offering teaching enhancement courses for elementary school teachers on the Navajo Reservation.

As a member of the National Physics Education Collaboration, which encourages minority college students to pursue advanced degrees in physics, we sponsor nearly 20 minority physics students,

selected nationwide, in an eight-week summer research project. This program, in collaboration with California State University, Hayward, is to increase the pool of physics researchers by increasing the number of students pursuing advanced degrees in physics.

As a member of the National Physical Science Consortium, a collaborative effort among academia, business, and industry to prepare women and minorities for careers in the physical sciences, we support women and minority students earning advanced degrees in chemistry and physics. This year 15 students from institutions throughout the country came to the Laboratory to do research for their doctoral degrees. The first such student from LLNL to achieve a Ph.D. will be graduating during the coming year.

Teacher Certification Program

Two years ago, in collaboration with representatives from San Jose State University, LLNL's Employee Development organization initiated a program in which Laboratory employees with advanced degrees in science or math could earn a single-subject secondary teaching credential. The first class consisted of 24 students with specialties in physics, chemistry, geology, engineering, and math. We currently have students practice teaching at several junior and senior high schools in the area; our first students will receive their credentials in January 1995.

Summary

We are developing new science curricula, changing the way science is taught, providing enrichment opportunities for teachers, bringing technology to the classroom, and providing more opportunities for students to do research and earn advanced degrees. We hope to stimulate greater interest in science among teachers, students, and administrators; encourage more students to pursue careers in science; and foster a technically and scientifically literate generation. Our ultimate goal is to help shape a work force that can produce the scientific and technological innovations needed to sustain a strong national economy and a competitive edge in the world marketplace.

Figure 5. Students from Hart-Ransom School in Modesto, California, conduct water-monitoring research in the field with LLNL "mentors" as part of the Student Science Research Associates (SSRA) Water Quality Project.

Notes and References

1. For more information on the Laboratory-developed sensors for the Clementine satellite cameras, see the June 1994 issue of *Energy and Technology Review* (UCRL-52000-94-6).

2. This server will also be available to other national laboratories for the same purposes.

3. At last count, SEABA included four national laboratories; several offices of education; the California state universities; the U.S. Geological Survey; Marine World Africa USA, Vallejo, California; the Monterey Bay Aquarium; the San Francisco Exploratorium; the Corporation for Public Broadcasting, KQED, San Francisco; the California Academy of Sciences; NASA Ames Research Center; and the San Francisco Zoological Society.

4. In 1990, Cray Research, Inc., donated one of its supercomputers to the DOE for the sole purpose of education. Today this computer, known as the National Education Supercomputer is housed in the National Energy Research Supercomputing Center at LLNL.

5. The schools associated with this program include Howard University, North Carolina A&T State University, Southern University and A&M College, Spelman College, Morehouse College, Fisk University, Fort Valley College, Clark Atlanta University, Alabama A&M University, Jackson State University, and Prairie View A&M University.

For further information contact
Eileen Vergino 424-0567.